**Appendix A1)**

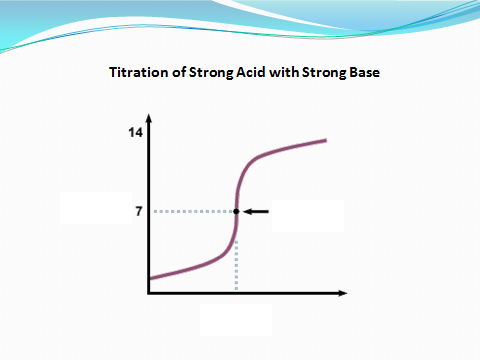
**Titration Curves of Strong acid/Strong base and Weak acid/Strong base titrations**

1. *Strong acid/strong base*
2. What do we plot of the x-axis? What do we plot of the y-axis
3. *Titrant volume on the x-axis and pH on the y-axis*
4. If we are titrating a solution of HCl with known molarity with a solution of NaOH with unknown molarity, which solution will our titration curve represent?
5. *The titration curve serves to profile the unknown solution*
6. Locate the region of the curve where the equivalence point would be.
7. *The equivalence point is on the vertical portion of the curve.*
8. What does the equivalence point represent?
9. *The equivalence point represents the point where the base has completely neutralized the acid.*
10. How is this different from the endpoint of a titration?
11. *The endpoint refers to the point at which the indicator changes colour in a colorimetric titration. It is close to the equivalence point but occurs slightly afterwards.*
12. When titrating a strong acid with a strong base, at what pH will you find the equivalence point?
13. *pH=7*
14. Why do you think the equivalence point will be at a pH of exactly 7?
15. *Equivalence point is at pH = 7 because the salt produced does not undergo any* [*hydrolysis reactions*](http://www.sparknotes.com/chemistry/acidsbases/phcalc/section1.rhtml#hydrolysis)*.*
16. *Weak acid/strong base*
17. How is this curve different from the previous one?
18. *The shape is different. There is a lag time at the start of the curve. The equivalence point is above 7.*
19. Why do you think there is a lag time before the equivalence point is reached?
20. *There is a lag in reaching the equivalence point, as some of the weak acid is converted to its conjugate base.*
21. What is this region of the curved called?
22. *The buffering region. In the buffering region, it takes a large amount of NaOH to produce a small change in the pH of the receiving solution.*
23. In this case, do you think that the pH at the equivalence point will be 7? Why or why not?
24. *Because the conjugate base is basic, the pH will be greater than 7 at the equivalence point. You can calculate the pH using the* [*Henderson-Hasselbalch equation*](http://www.sparknotes.com/chemistry/acidsbases/buffers/section1.rhtml#hendhass)*.*

http://img.sparknotes.com/figures/0/011855caec1598bc1bbf023fcd779bae/hh.gif

Note : Within the buffering region is something called the ½ equivalence point. This is the point at which the pH of the solution is equal to the pKa.

Note : The pH of a solution at the equivalence point has nothing to do with the volume of titrant necessary to reach the equivalence point; it is a property inherent to the composition of the solution.

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**Appendix A2) Lab Safety Review Teacher’s Notes:**

* All students should wear: Lab coat, safety goggles, gloves
  + All long hair is to be tied back. Close-toed shoes are to be worn.
* Review WHMIS information and explain properties of chemicals being used (HCl=acid, NaOH=base)
  + They will be dilute concentrations, but caution should still be emphasized
* Show where eye wash station is, safety blanket, fire extinguisher
* NO EATING or DRINKING in lab!
* If anyone has an open wound (e.g. cut) please cover with a Band-Aid before beginning experiment
* If there are any spills, report immediately. If there is broken glassware, report immediately (separate garbage for broken glass)

**Appendix B1) Lab Procedure Handout**

**SCH4U**

**Name: Date:**

**Titration of a Strong Acid With a Strong Base**

**Introduction:**

*Neutralization* occurs when the hydronium ion from an acid interacts with a hydroxide ion from a base, in a 1:1, that forms water in the process. A salt is always a byproduct of this type of reaction. *Titration* is the progressive addition of an acid to a base to achieve neutralization. The point at which there are equivalent amounts of acid and base is called the end point (equivalence point).

**Purpose:**

Students will conduct an acid-base titration to solve for the unknown concentration of the acid in the experiment. This will solidify the comprehension of neutralization reactions and calculations involved in acid-base equilibria.

**Materials:**

10mL graduated cylinder Phenolphthalein Indicator

50mL graduated cylinder 1 M NaOH

Retort Stand ‘X’ M HCl (unknown concentration)

Burette Clamp Funnel

50mL burette pH paper

250mL flask Pipette

150mL beaker (2) Goggles + Apron

**Procedure:**

1. Work in groups of 2-3 people. Obtain all necessary equipment and set up for the titration.
2. Clamp the burette to the retort stand.
3. Carefully pour (using a funnel) 12mL of 1 M NaOH into the burette.
4. Pour 5mL of the unknown concentration of HCl in a 250mL flask and place under the tip of the burette (*NOTE: Make sure nozzle on burette is closed BEFORE placing flask underneath!)*
5. Add 2 drops of phenolphthalein indicator to the HCl just before beginning the titration.
6. Slowly dispense NaOH from burette (turn nozzle to open) to the flask holding the acid-indicator solution. Stop titration when solution turns a ***faint*** pink. This is the equivalence point.
7. Record volume of NaOH that was needed to reach the equivalence point.
8. Pipette a small amount of neutralized solution from flask and drop onto pH paper. Record pH of solution.
9. Repeat steps 4-8 two more times for a total of **THREE** trials. (*NOTE*: *You can empty flask of HCl down the drain between trials since it is a dilute solution)*. Make sure each partner performs one titration.
10. Average the volume of NaOH used in the three trials and record.
11. Record all data in a table.
12. Clean up work station.

**Observations:**

Table 1.0-Data Collected from Titration of HCl with 1 M NaOH

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Volume NaOH Used** | **Colour of Solution Before/After equivalence reached** | **pH of solution** |
| **Trial 1** |  |  |  |
| **Trial 2** |  |  |  |
| **Trial 3** |  |  |  |
| **Average Volume** |  |

**Proper Use of a Burette**

1. Rinse the burette with clean distilled water several times.
2. Arrange the ring stand, burette clamp and burette on the stand as seen in the picture to the right.
3. Place a funnel on the top of the burette. Make sure burette is closed at the bottom and fill with titrating solution, past the zero mark.
4. Place a beaker under the burette and let some of the titrant through, to fill the tip and titration to the zero level . Be sure there are no air pockets near tip of burette.
5. When reading the burette always read the bottom of the miniscus (curve of the water) and hold a white card behind the burette to make it easier to read.
6. After adding the titrant touch the end of the tip of the titrant to the side of the glass container to remove any excess drops.
7. Rinse burette thoroughly with clean water when finished

**Appendix B2a) Lab Questions and Lab Instructions Handout**

**SCH4U**

**Name: Date:**

**Titration of a Strong Acid and Strong Base** *- Lab Report Instructions and Questions*

**Due Date: NEXT CLASS**

Instructions for Lab Report

A formal lab report will NOT be handed in. Listed below are Data Analysis questions related to the titration lab performed. Use your observations from the experiment, and answer the following questions.

**Data Analysis:**

1. The purpose of the experiment was to identify the concentration of HCl used in the titration. Using your knowledge of neutralization reactions and the recorded observations from the experiment, calculate the concentration of HCl.

*HINT: Begin by writing out the chemical reaction taking place. Remember mole ratios.*

1. What was the average pH of the neutralization reaction once the equivalence point was reached? Show by using calculations. Compare your calculation to your results obtained from using pH paper during the experiment.
2. Explain why phenolphthalein was chosen as the indicator for this particular experiment. If the stock of phenolphthalein ran out during the lab, would methyl orange indicator be an appropriate replacement? Why or why not?
3. What are some experimental errors that occurred in the lab?
4. How would this experiment change if a weak acid were used instead of HCl? Make reference to the titration curve and explain the different regions.
5. Use the theory from Question 5 to solve the following problem: What is the pH at the stoichiometric point of the titration of 0.15L of 0.5M acetic acid with 2.5M KOH solution? (*Ka=1.8 x 10-5)*

**Appendix B2b)- Answer Key**

Molarity of HCL= 0.5M

**Data Analysis:**

1. HCl + NaOH 🡪 NaCl + H2O

-Mole ratio between HCl : NaOH is 1:1

What we know:

Average volume of NaOH used/titration= ~2.5mL

Molarity of NaOH = 1M

Calculate Moles of NaOH:

Moles of NaOH: n= M x V

n= 1M x 0.0025L

n= 0.0025mol

Therefore, moles of HCl= 0.0025mol

Calculate Molarity of HCl:

Moles of HCl= 0.0025mol

Volume of HCl= 5mL

Molarity of HCl: M= n / V

M= 0.0025mol / 0.005L

M= 0.5M

1. For a strong acid and strong base:

We know at the equivalence point that [OH-] = [H+]

Kw= [H+] [OH-]

10-14= [H+] [OH-]

*Since H+ = OH-*

√10-14= 10-7= [H+]=[OH-]

pH= - log [H+]

pH= - log [10-7]

pH= 7

1. –Phenolphthalein is a base indicator that changes colour at a basic pH

* pH (0)🡪 pH (8.1)= Clear
* pH (8.2) 🡪 pH (12.0) = Pink
* At the equivalence point of a strong base with strong acid: [H+]=[OH-]= pH of 7
  + We cannot see this equivalence point with the naked eye, but can choose an indicator that can signal when we are CLOSE to it. Therefore, we will add slightly more base than required until the pH reaches ~8.2 which causes the phenolphthalein to produce a colour change which signals us to STOP titrating. We stop titrating when we SEE a colour change. Phenolphthalein is an indicator that allows a close prediction of when the equivalence point is reached. It is not 100% accurate, but it is a better choice than most other indicators.
* What about methyl orange?
  + BAD replacement. Methyl orange is an acid indicator. The equivalence point is at a pH of 7 and methyl orange changes colour at much lower pH’s.
  + Therefore, will NOT produce accurate results.

1. –paralax

-accuracy of indicator

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-pH=pKa at ½ equivalence point

-at the beginning of the titration, the acid and H2O are the major species

-in the buffer region, the acid and its conjugate base are the major species. pH changes are slow here. Use buffer equation🡪http://img.sparknotes.com/figures/0/011855caec1598bc1bbf023fcd779bae/hh.gif

-when almost all acid has reacted with base, there is a sharp increase in pH to a point where there is excess conjugate base and base.

1. Mol OH- added= mol CH3CO2H

Keq=Kw/Ka

Keq=5.6 x 10-10

nOH added=Macid x Vacid=0.075mol

n (CH3CO2H) = 0.075mol

Vtitrant= 0.075mol/2.5M=0.03L

Vtotal= 0.15L + 0.03L= 0.18L

[CH3CO2H]initial=0.075mol.0.18L=0.417M

**ICE table**

Keq=x2/0.417-x

pH=9.18

**Appendix C1) Sample Calculation**

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**CHALKBOARD NOTES**

**CLASS AGENDA:**

1. Titration Curve Review
2. Lab Safety Review
3. Lab Demonstration
4. Titration Lab Activity
5. Lab station/classroom clean up
6. Sample Calculation + HomeFUN